CARDIOLOGY

Advanced Anatomy of the Pericardium

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Pericardium
PERICARDIUM

Consists of an **outer fibrous layer** (Fibrous pericardium) & **inner serous layer** (serous pericardium) that is further subdivided into parietal & visceral layers.
Fibrous Pericardium
It is formed of compact collagenous fibrous tissue
It is conical in shape having:

**APEX**: surrounds SAP blending externally with their adventitia, then continues more superiorly with pretracheal fascia. **N.B.** Lower ½ of SVC lies inside the pericardium, whereas lig. arteriosum lies outside it.

**BASE**: Rests of the diaphragm (its central tendon & a small muscular area of its left half) & is pierced by IVC on its Rt. side.

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FIBROUS PERICARDIUM

4 Ant.
- Thymus
- Sternum
- Sterno-pericardial ligaments
- Ant. borders of pleura & lung except at the bare area of pericardium (opposite Lt. 4th & 5th ICSs.)

4 Lat.
- Phrenic N.
- Pericardio-phrenic A. & V.
- Ant. Border of pleura
- Ant. Border of lung

4 Post.
- Oesophagus
- Oesophageal plexus
- Descending aorta
- Middle 4 thoracic vertebrae
Pulmonary veins pierce the pericardium at the meeting of its lat. & post. walls.
Notes about FIBROUS PERICARDIUM

1) The extent of the ‘sternopericardial ligaments' is extremely variable, and the superior one is often undetectable.

2) The fibrous pericardium is securely anchored by its relations & connections and maintains the general thoracic position of the heart, serving as the 'cardiac seat belt'.

3) The aorta, superior vena cava, right and left pulmonary arteries and the four pulmonary veins: all receive extensions of the fibrous pericardium. However, the inferior vena cava, which traverses the central tendon, has no such covering.
Serous Pericardium
The serosal pericardium is a single layer of flat cells on a thin subserosal layer of connective tissue, which blends with:

1) The fibrous pericardium forming the parietal layer.
2) The interstitial myocardial tissue forming the visceral layer.
On the cardiac side, the subserosal layer contains fat:

- It is present especially along:
  a) Ventricular side of the atrioventricular groove.
  b) Inferior cardiac border.
  c) Interventricular grooves.

- In this fat, the main coronary vessels and their larger branches are embedded.

- Its amount is related to the general extent of body fat and gradually increases with age.
@ Is invaginated by the heart from above & behind.

@ Upper border of the heart is the site of meeting of the 2 layers of the serous pericardium, i.e. around the roots of the great vessels.

@ Upper border of the Lt. atrium is the only part of heart bare off pericardium.
<table>
<thead>
<tr>
<th>Parietal layer</th>
<th>Visceral layer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lines</strong> the inner surface of fibrous pericardium</td>
<td><strong>Covers</strong> the heart &amp; is called epicardium</td>
</tr>
<tr>
<td><strong>Its N.S.</strong> = that of fibrous pericardium = phrenic N.</td>
<td><strong>Its N.S.</strong> = that of heart = vagus N. &amp; symp. chain</td>
</tr>
<tr>
<td><strong>Its Blood Supply</strong> = that of fibrous pericardium = • Pericardio-phrenic • Musculo-phrenic • Descending aorta • Azygos &amp; hemiazygos Vs.</td>
<td><strong>Its Blood Supply</strong> = that of heart = Coronary As. &amp; Coronary sinus</td>
</tr>
</tbody>
</table>

| Vs. | Forms a **tubular** sheath around the **A.** end of the heart (**AA & PT**) & forms a **J-shaped** sheath around the **V.** end of the heart (**SVC, IVC & pulm. Vs.**) |

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![Diagram of heart and pericardium]
Pericardiophrenic vessels & phrenic N.
Normal function of pericardial fluid

1) Prevents friction from occurring when the heart beats.
2) Provides for a particular biochemical microenvironment that bathes the epicardial coronary vessels and myocardium.

Therefore, the pericardial space may constitute an ideal site for local drug delivery to prevent and treat:

a. Coronary restenosis.
b. Myocardium ischemia and/or disease and arrhythmia,

via local anti-proliferation, angiogenesis and anti-arrhythmia agent instillation.

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Applied Points
Pericardiocentesis (Drainage of fluid from the pericardial cavity)

- Is usually necessary to relieve cardiac tamponade.
- Can be done via 3 methods:
  1) A wide-bore needle may be inserted through the left 5th or 6th intercostal space near the sternum (i.e. through the cardiac notch in the left lung and the shallower notch in the left pleural sac leaving a part of the pericardial sac exposed).
  2) By entering the infrasternal angle and passing the needle superoposteriorly (to avoid the lung and pleura) and enters the pericardial cavity; however, care must be taken not to puncture the internal thoracic artery or its terminal branches).
  3) In acute cardiac tamponade from hemopericardium, an emergency thoracotomy and the pericardial sac is rapidly opened.
Percutaneous pericardial access
Percutaneous access of the normal pericardium

Other inclinations lead to:
1) Diaphragmatic bleeding
2) Liver injury

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Percutaneous access of the normal pericardium

- An initial percutaneous tunnel is made below the xiphoid process using a 21-gauge blunt cannula advanced nearly parallel to the skin surface, using 2 approaches:
  a) The typical anterior approach.
  b) An inferior approach.

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Anatomy of this area deals with

I. **Diaphragm**

II. **Supra-diaphragmatic structures:**
   1) Coronary As.
   2) Internal thoracic artery
   3) **Phrenic Ns.**
   4) Pleura & lungs

III. **Infra-diaphragmatic structures:**
   a) Liver.
   b) Spleen.
   c) Colon.
   d) Diaphragmatic vessels.

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I. Diaphragm

- **Viewed from ant. aspect**: it has:
  
  a) **A cardiac plateau** (equivalent to the central tendon) at the level of 6th cc or the lower end of sternum.

  b) From the cardiac plateau, the diaphragm curves into **Rt. & Lt. domes or cupolae**: Rt. is higher (reaching up the nipple = Lt. 4th ICS) than the Lt. (at the level of Rt. 5th rib).
I. Diaphragm

- **Viewed from side aspect**: it has resembles an **inverted J**:

  1) **Its long limb**: extends up the crura (attached to the upper lumbar vertebrae).

  2) **Its short limb**: is attached to xiphoid process of sternum (T8 vertebrae).
I. Diaphragm

- **Viewed from above**: its outline is kidney shaped:
  1) **Its circumference**: conforms with oval outline of the body wall.
  2) **Its indentation**: is present posteriorly (by the vertebral column).

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I. Diaphragm

• Being derived from the “innermost M. layer of the AAW” transversus abdominis, the diaphragm fibers are in continuity with (or interdigitates with) the transversus abdominus M.
I. Diaphragm

• A potential window exists lateral to the xiphisternum at the angle it meets the costal margin where puncturing may result in being above the diaphragm directly toward the fibrous pericardium that attaches to the thoracic wall.

• The size and accessibility of the window depends on the patient's body habitus and individual anatomy.
I. Diaphragm

• The diaphragm arches back in a “parachute” shape to a maximum height equivalent to the sternal–xiphisternal junction at the midline. Thus, a needle must be angled parallel to the “parachute,” to reach the heart, which rests on the central tendon.

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I. Diaphragm

• **Superior (Thoracic) relations**: 3 serous membranes containing 3 organs =

1) 2 Pleurae containing 2 lungs **(above the 2 cupolae)**.

2) Pericardium containing heart **(above the cardiac plateau = central tendon)**.
I. Diaphragm

- **Inferior (Abdominal) relations:**

<table>
<thead>
<tr>
<th>Below Rt. cupola</th>
<th>Below Lt. cupola</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rt. lobe of liver</td>
<td>Lt. lobe of liver</td>
</tr>
<tr>
<td>Rt. colic flexure</td>
<td>Lt. colic flexure</td>
</tr>
<tr>
<td>Rt. kidney</td>
<td>Lt. kidney</td>
</tr>
<tr>
<td>Rt. suprarenal</td>
<td>Lt. suprarenal</td>
</tr>
<tr>
<td><strong>Stomach</strong></td>
<td><strong>Spleen</strong></td>
</tr>
</tbody>
</table>
II. Supra-diaphragmatic structures:

1) Coronary As.

- With the typical anterior approach, needle puncture of the coronary arteries is very uncommon.
- With an inferior approach, there is an increased but still small risk of damage to the right posterior descending artery (R.P.D.).
II. Supra-diaphragmatic structures:

2) Internal thoracic A.
INTERNAL THORACIC ARTERY

- **Origin**: 1<sup>st</sup> part of the subclavian artery.
- **Course**: passes inferiorly, parallel to the sternal border running almost vertically **1.25 cm (1/2 inch)** from the sternal edge, accompanied by a pair of veins (where it gives off perforating vessels to the chest wall and mammary tissue, (hence also previously called *internal mammary artery*).
- **Termination**: At the 6<sup>th</sup> intercostal space by dividing into the musculophrenic and superior epigastric arteries (the latter of which passes in *Larry’s space = sternocostal trigone = foramen of Morgagni*) between the sternal & costal origins of the diaphragm.
Inferior to its bifurcation, the distance from the internal thoracic artery to the sternum and inferiorly to the xiphoid process increases, minimizing risk of its injury.
II. Supra-diaphragmatic structures:

3) Phrenic Ns.

- Both phrenic nerves travel with the pericardiophrenic vessels.
The phrenic nerves run bilaterally along the borders of the pericardium, between the fibrous pericardium and the mediastinal pleural layers.
II. Supra-diaphragmatic structures:

3) Phrenic Ns.

- The **right phrenic nerve** descends immediately anterior to the right superior pulmonary vein.
- The **left phrenic nerve** passes onto the pericardium overlaying the left atrial appendage.
II. Supra-diaphragmatic structures:

3) Phrenic Ns.

• Therefore, **phrenic nerves** may be damaged by ablation overlying the:
  
a) Posterolateral right atrium.
  
b) Right superior pulmonary vein.
  
c) Left atrial appendage.
  
d) Lateral left ventricle.
II. Supra-diaphragmatic structures:

4) Pleura & Lungs

- If the puncture is initiated in the **paraxiphoid sternocostal trigone**, it is unlikely that the needle will reach the pleura & lung.

- **However, pneumothorax may occur in the following conditions:**
  a) A laterally placed infrasternal puncture.
  b) The needle was angulated too far in the lateral direction.
III. Infra-diaphragmatic structures:

1) Liver

- The anterior margin of the liver extends to a line approximately on the upper third of the abdomen between the xiphisternum and umbilicus, roughly at the level of the costal cartilage of the 9th ribs.
- From there it arcs posteriorly and comes to the diaphragm at the level of the sternal–xiphisternal junction.
III. Infra-diaphragmatic structures:  

1) Liver

- The left lobe of the liver crosses the midline and represents a possible site of injury should the access needle enter the peritoneum.
- **Hepatomegaly** is a potential risk factor for complication, increasing the risk of liver puncture with the subxiphoid approach.
- Puncture of the liver with just the needle is often well tolerated, but is best avoided.
III. Infra-diaphragmatic structures:

2) Spleen

- The spleen lies lateral to the Lt. lobe of the liver, between the gastric fundus and the diaphragm.
- In the absence of splenomegaly, there is little risk of splenic puncture.

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• Although an uncommon complication, this may necessitate surgical intervention.
III. Infra-diaphragmatic structures:

4) Diaphragmatic vessels

- Although an uncommon complication, this may necessitate surgical intervention for intraperitoneal hemorrhage.

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